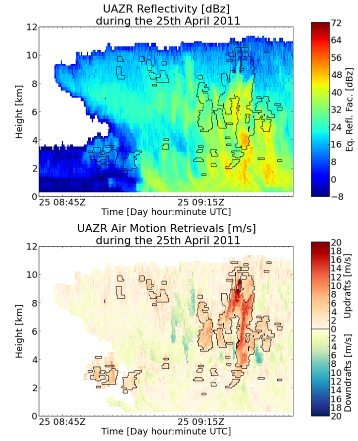
New Insights Into Deep Convective Core Vertical Velocities Using ARM UHF Wind Profilers

Research Highlight

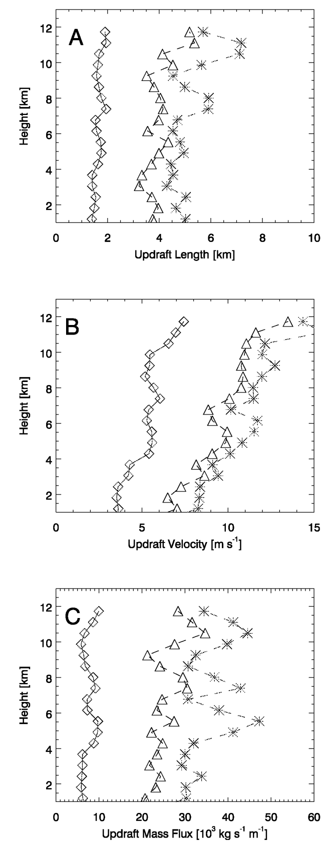
Substantial uncertainty in global climate model (GCM) predictions of possible climate change can be attributed to the representation of the effects of deep cumulus convection. One important limitation when elucidating the complex interactions between storm dynamics, thermodynamics, and microphysics of deep convection is the practical hazard associated with obtaining direct measurements from within intense convective environments. This includes the measurements of vertical velocity within these deep convective cores, a quantity of known interest as a constraint to the connections between humidity, entrainment, and microphysical treatments of storm-resolving models. Given known aircraft restrictions for flying directly into deep convective clouds, there is a need to advance remote sensing solutions that encourage longer-term cumulative convective characterization to facilitate cumulus representation in models.

We explore one possible solution: extended deployments of radar wind profilers to estimate vertical air motions in convective systems. Recently, the Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Climate Research Facility in Oklahoma (Southern Great Plains site, or SGP) reconfigured its existing 915-MHz (UHF) wind profilers to operate in vertically pointing modes to take samples through deep convection passing overhead. New operating modes unique to these commercial Vaisala 915-MHz UHF (33-cm wavelength) systems were implemented to better match the sampling requirements for capture of convective core properties typical for warm-season Oklahoma convective storms. Our study presents a summary of deep convective updraft and downdraft core properties over the central plains of the United States, accomplished using a novel and now-standard ARM scanning mode for these commercial wind profiler systems. We explore profiler observations collected during two extended ARM Oklahoma campaigns in 2009 and 2011 including the recent ARM Midlatitude Continental Convective Clouds Experiment (MC3E). Although these profiler observations cannot replicate aircraft sampling, the study adopts several standard definitions for diameter, intensity of vertical motion, and mass flux from previous airborne efforts.

Capitalizing on the measurements from profiling radars within continental convective thunderstorms has provided unique insights into vertical velocity for decades. Accuracy of the velocity retrievals from these profiler efforts are to within 2 ms-1 with minimal bias and updraft core resolution of 1 km. For the presented Oklahoma SGP data set, updraft cores are found having behaviors with height in reasonable agreement with previous continental convective aircraft observations including the Thunderstorm Project. Intense updraft cores with magnitudes exceeding 15 ms-1 are routinely observed. Downdraft cores are less frequently observed with magnitudes weaker than updrafts. Weak, positive correlations are found between updraft intensity (maximum) and updraft diameter length (r to 0.5 aloft). Negligible correlations are observed for downdraft core lengths and intensity. Future work will include routine processing of these ARM observations. Advancing these techniques within ARM will also be of additional benefit toward validation of proposed ARM multi-Doppler radar velocity retrieval methodologies in deep convection.



ARM UHF profiler observations of reflectivity Z (top) and retrieved storm vertical velocity (bottom); overlaid contours bound regions of updrafts greater than 1.5 m/s.



Summary median (diamond), 90th (triangle), and 95th (star) percentile data set properties of Oklahoma convective core updrafts including: (A) horizontal length, (B) velocity, and (C) updraft mass flux.

Reference(s)

Giangrande SE, S Collis, J Straka, A Protat, C Williams, and S Krueger. 2013. "A summary of convective core vertical velocity properties using ARM UHF wind profilers in Oklahoma." Journal of Applied Meteorology and Climatology, , . ACCEPTED.

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